Verification and Validation of OOV-TET1 Multispectral Camera Observations within the FireBIRD Project

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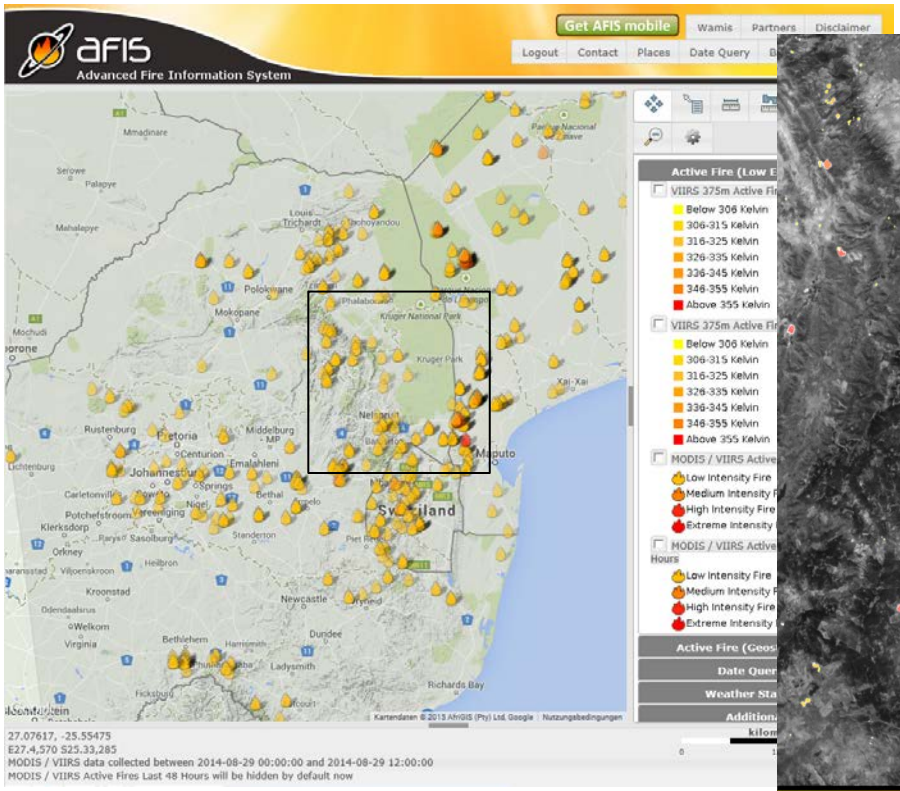
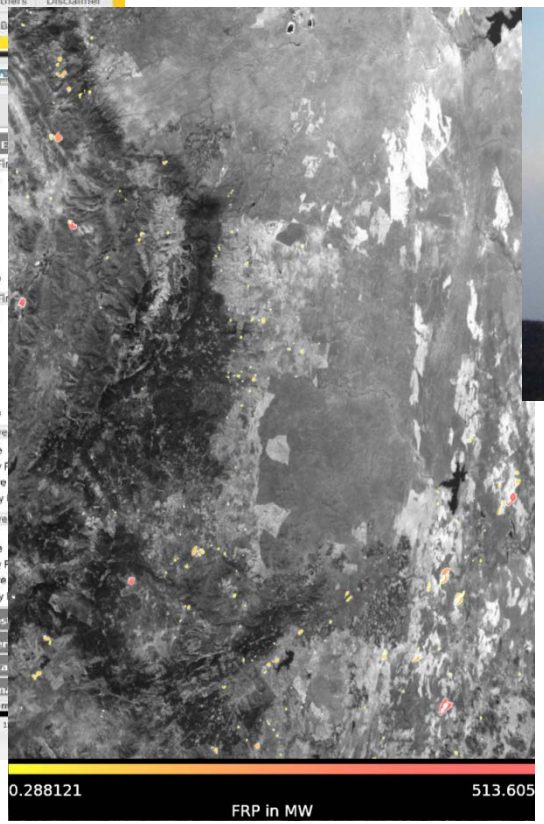
Why observations of Wildfires?

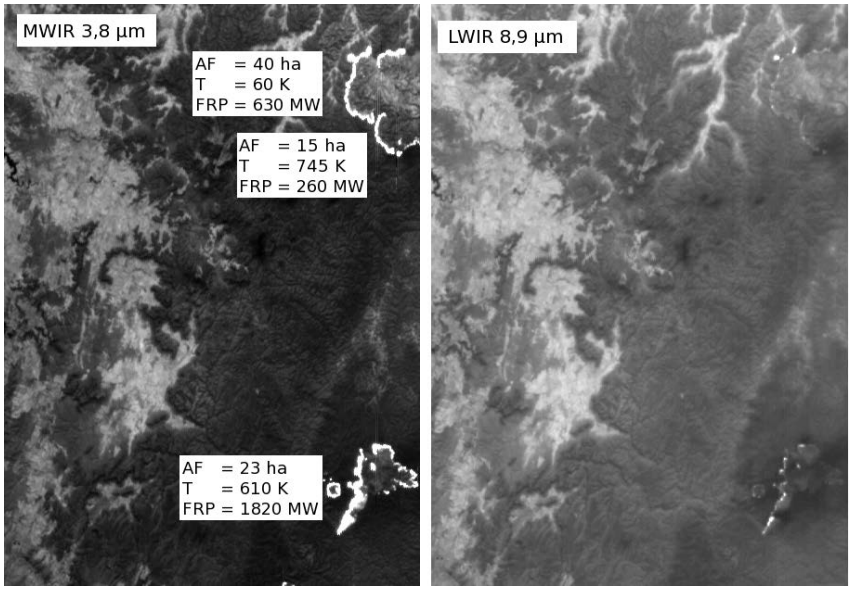


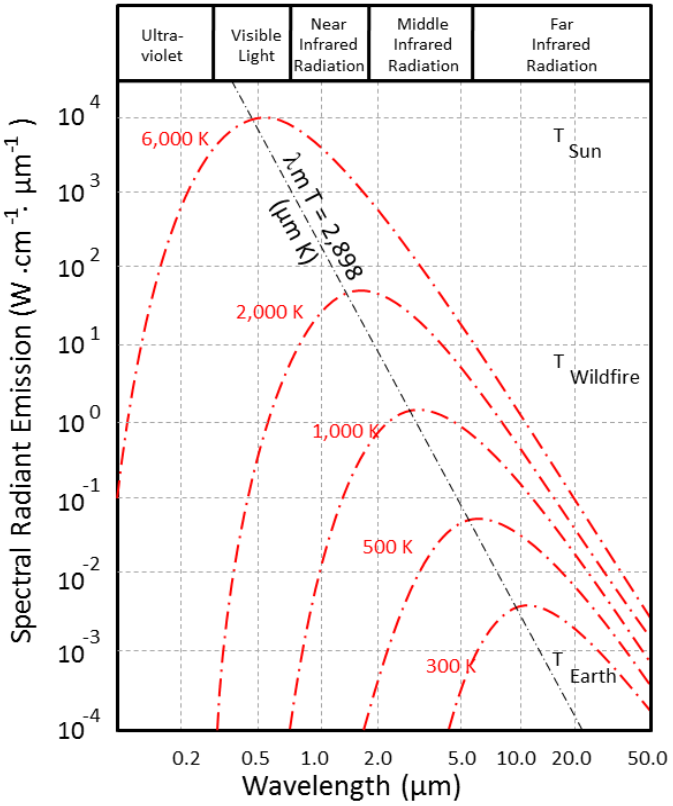


Republic of South Africa, 29. Aug. 2014
Advanced Fire Information System (VIIRS, MODIS)

Remote Sensing on Fires

- Wildfires with typically 1000K have a peak spectral radiance in MWIR
  - Same magnitude as sun glint
- Thermal background small
- Fire detection algorithm from B. Zhukow (adapted by Dozier):
  - MWIR for detection
  - LWIR for background estimation
  - Visible channel to screen out sun-glint



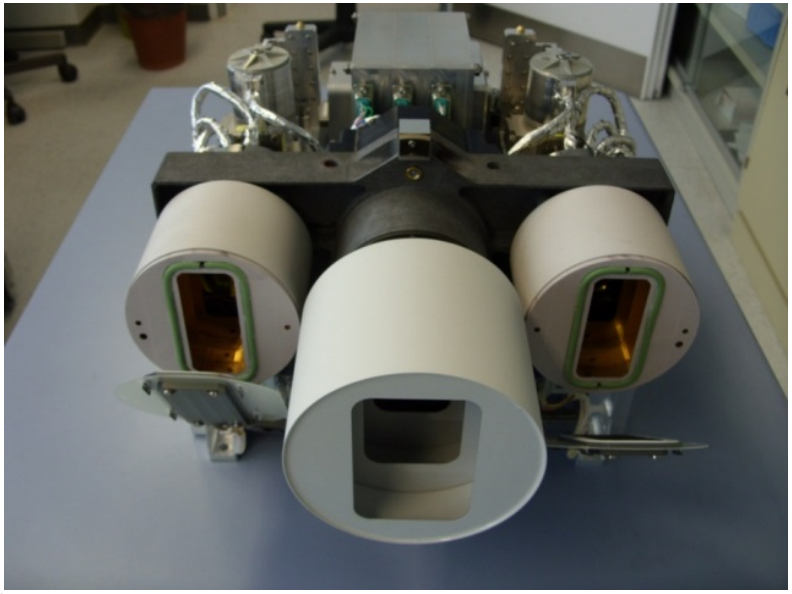


Blackbody emissive power spectrum. (adopted from Leblon et al., 2012)

TET-1 Datatake 26. Oct 2013,
Australia West of Sydney

OOV – TET1 Multispectral Camera Payload

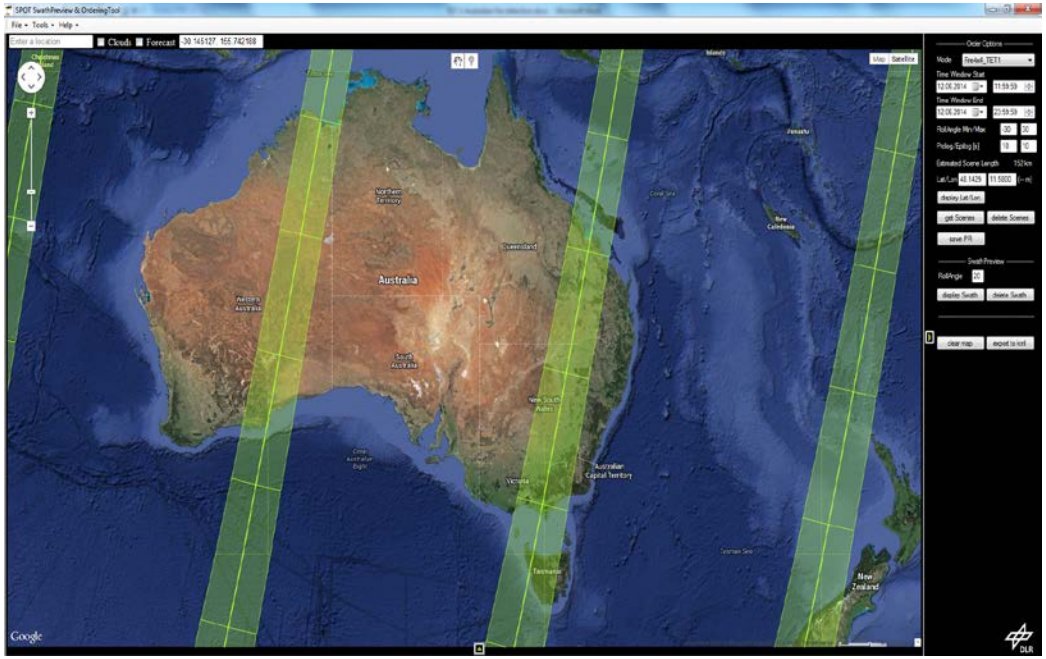
- IR-Camera:
  - Black-Body for In-Flight Calibration
  - Dwell time 20 ms,
  - Integration time 4 ms and 2.7 ms for hot areas on demand
- VIS Camera synchronized with IR camera



	3 line-VIS Camera (3 line FPA, 6 ° separated)	2 Infrared-Cameras (staggered lines)
Wave length	1 460 - 560 nm 2 565 - 725 nm 3 790 - 930 nm	MWIR: 3,4 - 4,2 µm LWIR: 8,5-9,3 µm
Detector	CCD- Zeile	CdHgTe Arrays
Detector cooling	Passive, 20 ° C	Stirling, 80 - 100 K
Pixel size	7 µm x 7 µm	30 µm x 30 µm
Number of Pixel	3 x 5164 (1250)	2 x 512 staggered
Quantization	14 bit	14 bit
Ground resolution	42,4 m 2)	356 m 2)
Ground sampling distance	42,4 m 2)	178 m 2)
Swath width	211 km 2)	178 km 2)
Data rate	max 44 MBit/s (11,2)	0,35 MBit/s
Accuracy	100m on ground	100m on ground
Main FireBird camera parameters 2) Altitude 510km		

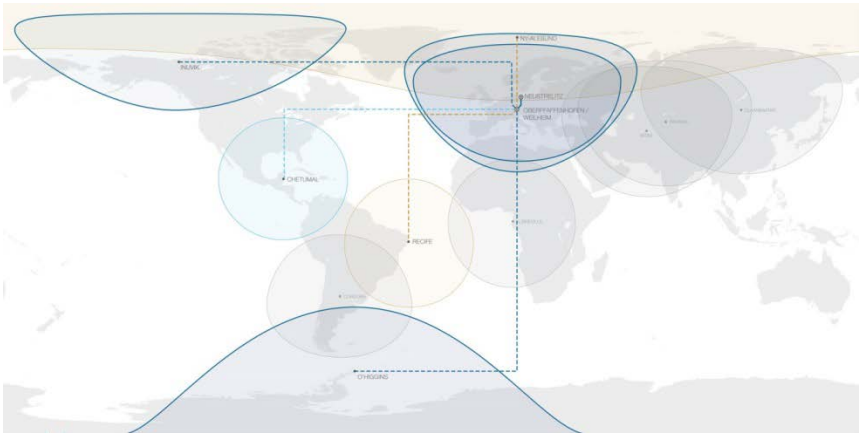
Mission Operation

- Target selection via orbit preview
- Selection of date, location, size and mode



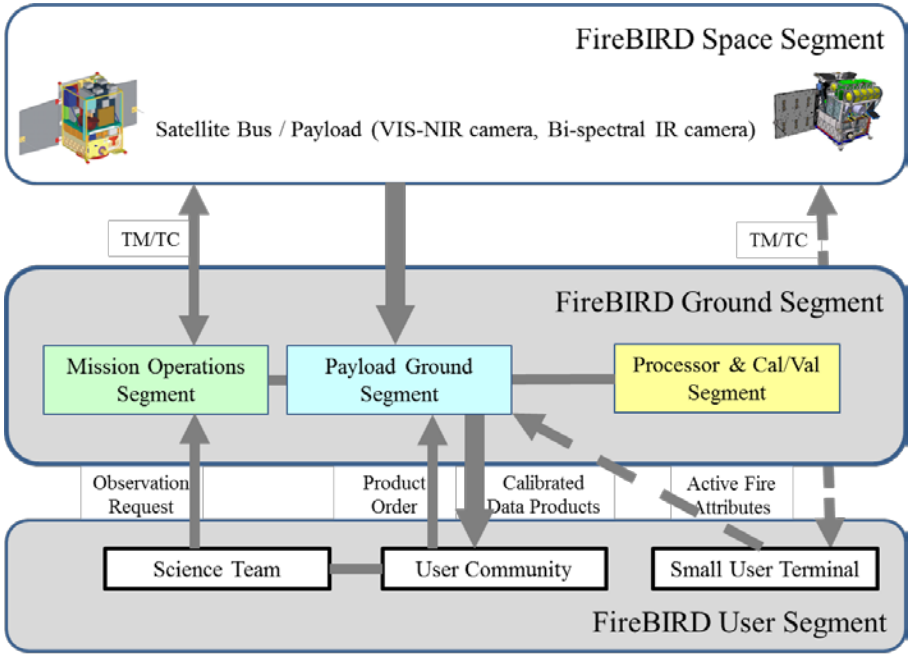
- Different predefined operational modes
  - Fire 4x4
  - VIS 3 full resolution (8-Bit)
  - VIS 1 full resolution
  - Systemorders:
    - Selection of radiometric and geometric resolutions
    - Variation of integration time
- Limitations due to:
  - Data transfer rate
  - On-board memory
  - Downlink capacity

Data Processing



- Data reception at DLR Ground Station Network
- Near-Real Time Processing (5 min) to L1B
- Operational L2 Fire product is planned
- Delivery via FTP
- Data inquiry via EOWEB

- L1B products as HDF-EOS5:
  - Spectral radiance TOA
  - Geo-located WGS 84
  - Can be converted to ENVI
- Level 2 Fire Products (Plan) as GeoTIFF + XML (OGC-EO)



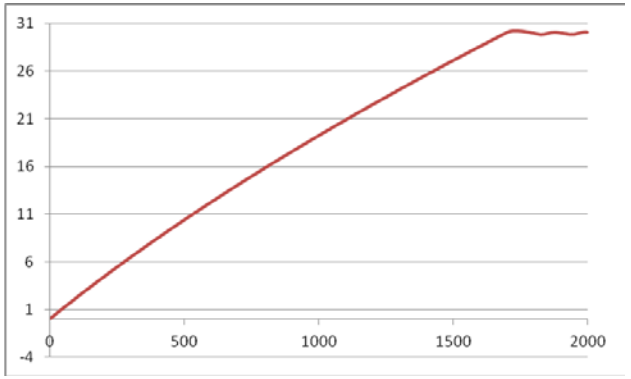
Calibration

- IR detector requires in-flight calibration for each cooling cycle
- Cooling works better than anticipated
  - Dark signal are lower than measured in ground calibration
  - Ground calibration is not applicable
- Long term calibration product will be generated for reprocessing to correct remaining artefacts or failed calibrations

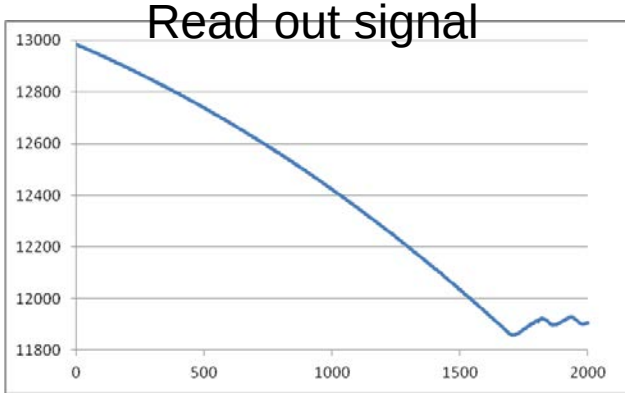
- VIS – dark signal is smaller than on ground
  - unveals an electronic pattern

- Geometric calibration
  - Still not perfect (appr. 1km)
  - Differences between Day and Night

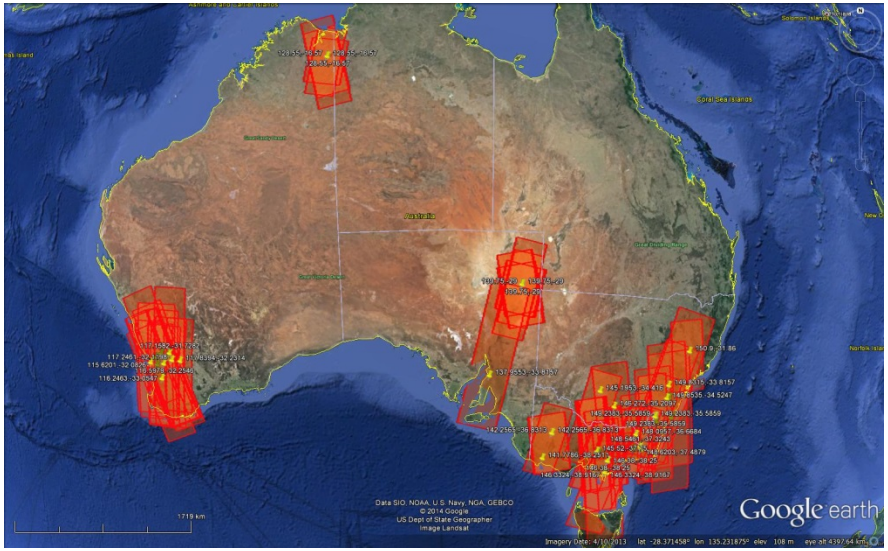
Flap temperature



Read out signal

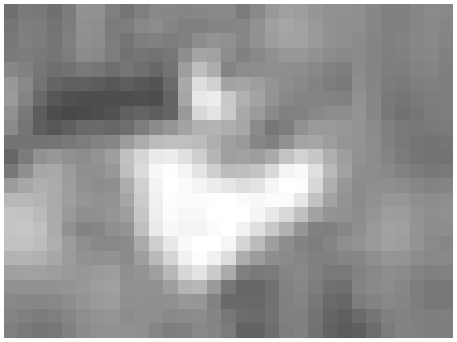


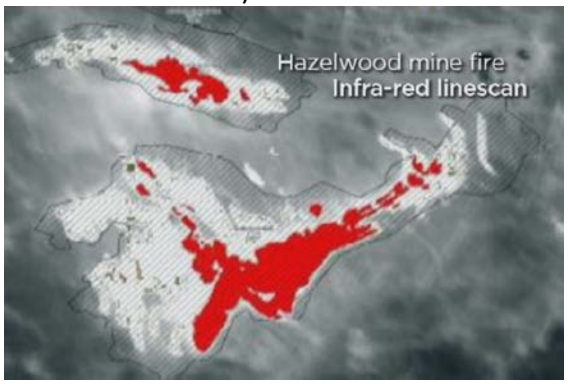
Case Study - Australia



- Fire occur in remote inaccessible loactions
- Wildfires lasting more than one day
- Regular prescribed burnings for hazard reduction

Hazelwood coal mine March 2014
Left: TET MWIR image
Right: Daedalus line scan (airborne)
(© DEPI/CFA State Aircraft Unit)

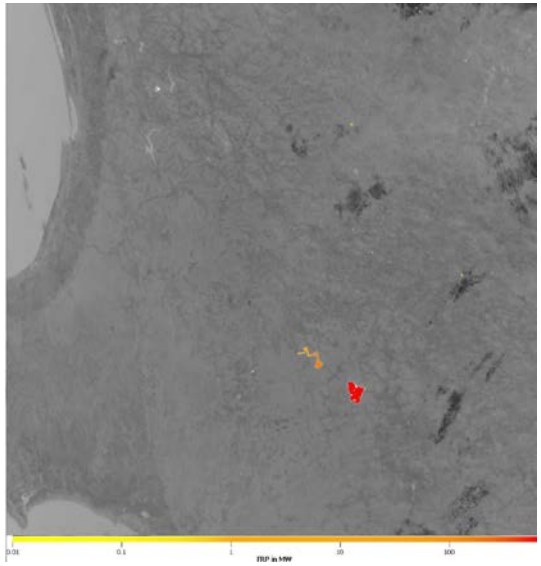


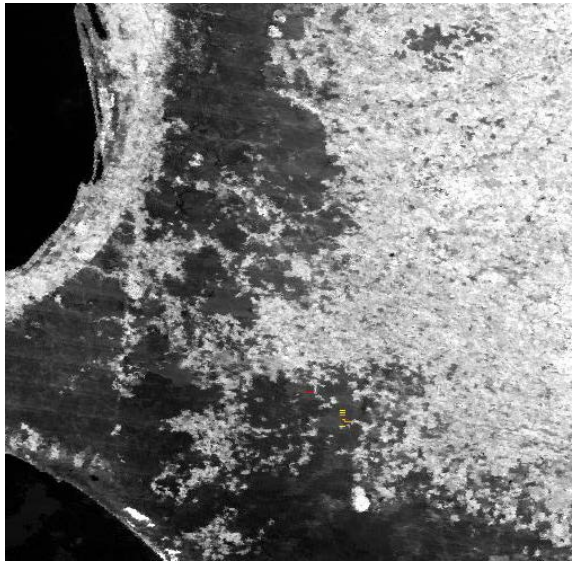


- Orbit not optimal for fast downlink
- Many datatakes obscured by clouds
- Collision of interests (Where to look at first?)

Comparison with MODIS MOD14 Hot Spot Detection

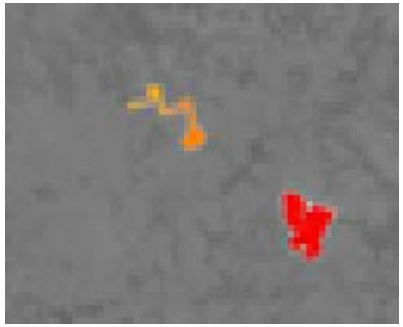
- Perth planned burns 5th April 2014 –
  TET 350 m (180 m GSD) MODIS 1 km Time difference 2 hours

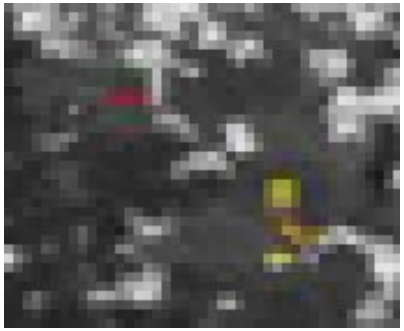




~100 MW

~ 500 MW

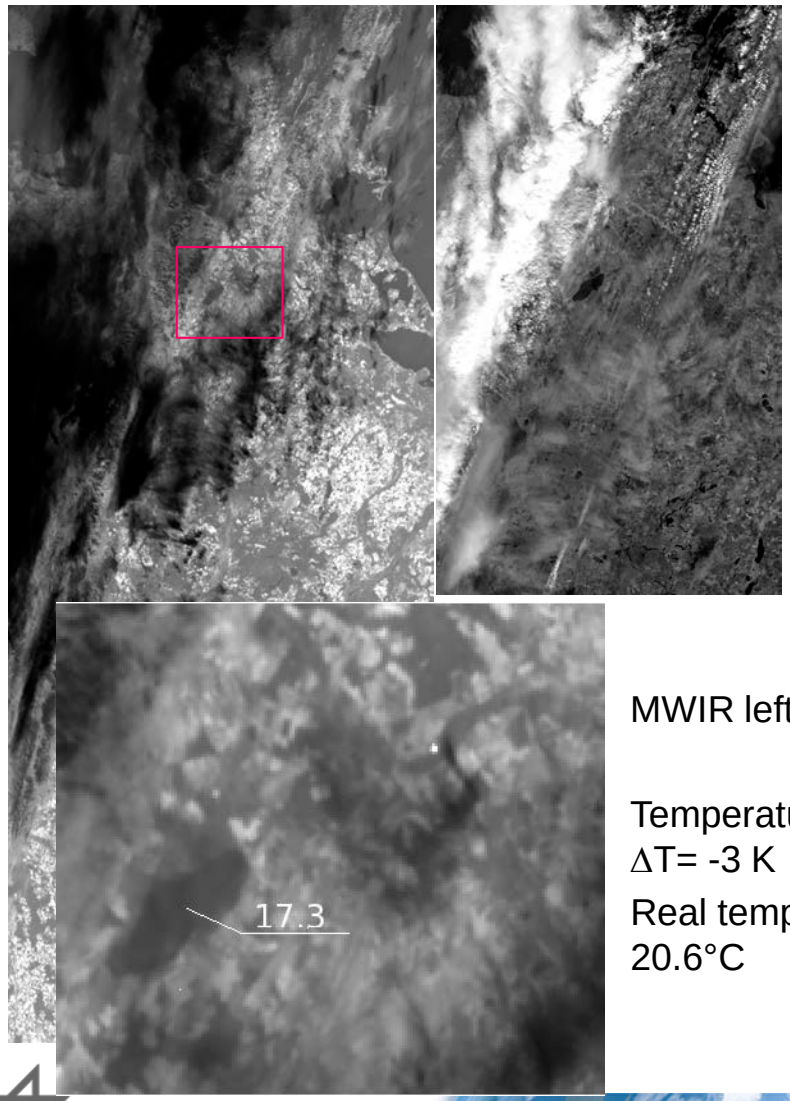




High Confidence

Low Confidence

Validation – Artificial Fire



MWIR left - NIR right

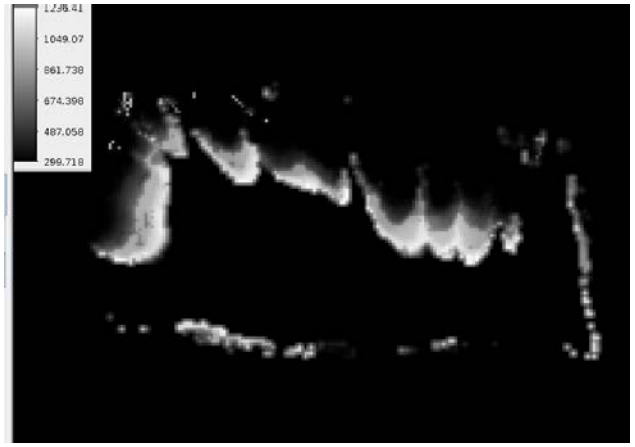
Temperature error:
ΔT= -3 K

Real temperature:
20.6°C

	Experimental Fire DEMMIN / Germany		
	TET-1	Ground	Ratio
T_{min}/ K	490		
T_{mean}/ K	727	940	0,77
T_{max}/ K	1500	1150	
AF_{min} / ha	0,001		
AF / ha	0,0141	0,0143	0,99
AF_{max} / ha	0,1733		
FRP / MW	2,24	1,36	1,65

Effects of variations of radiance with respect to fire parameters				
MW Radiance	100	100	100	150
LW Radiance	99	100	101	100
FRP / MW	2.4	2.7	3.2	4.1
T_F /K	889	744	669	942
A_F / m²	68	158	280	92

Wildfire Campaign – Kruger National Park / South Afrika

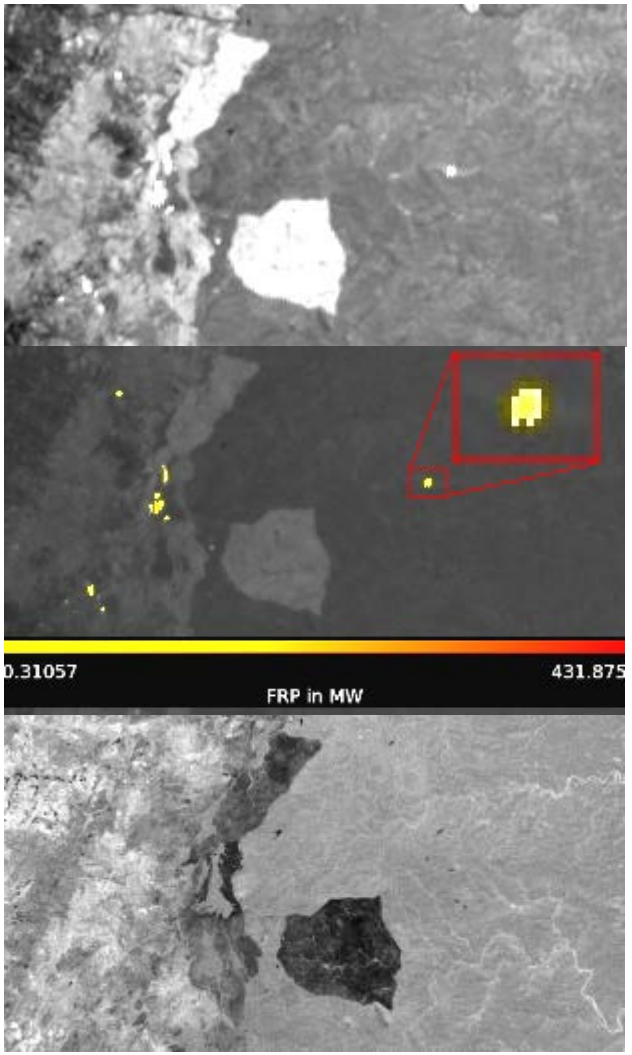


Thermal Image, from Helicopter
(Source: Paugam / Wooster, KCL)

MWIR

FRP

NIR



Wildfire Campaign – Kruger National Park / South Afrika

- Error in FRP within 35 % relative to ground data
- T_F and A_F within estimated margins
- Inhomogeneus background accounts for largest error

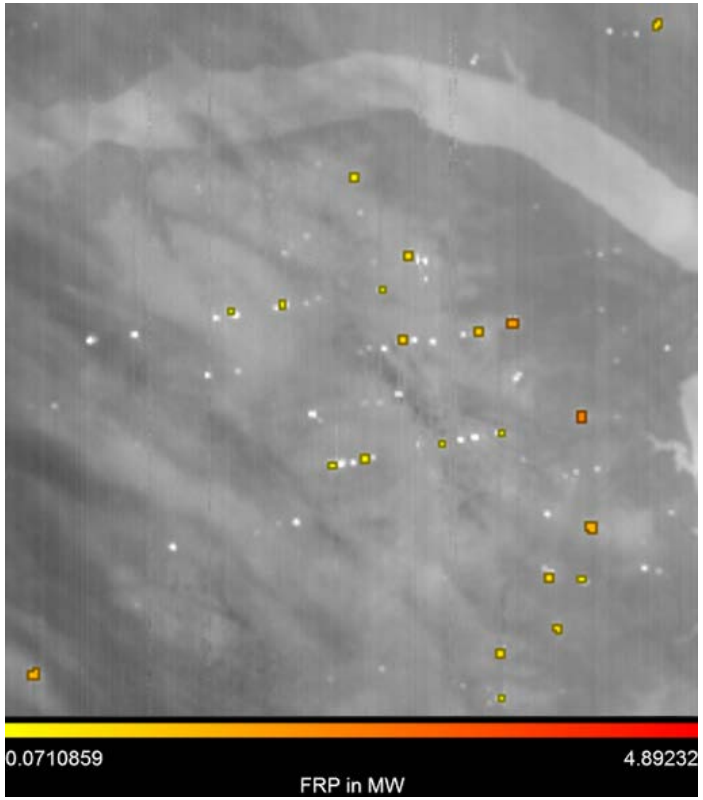
	Savannah Shabeni			Savannah Skukuza 6 Plot			Experimental Fire DEMMIN / Germany		
	TET-1	Helicopter	Ratio	TET-1	Helicopter	Ratio	TET-1	Ground	Ratio
T_{min}/ K	661	550		559	550		490		
T_{mean}/ K	685	668	1,02	580	595	0,97	727	940	0,77
T_{max}/ K	713	907		606	803		1500	1150	
AF_{min} / ha	0,15			0,36			0,001		
AF / ha	0,19	0,24	0,80	0,47	0,60	0,79	0,0141	0,0143	0,99
AF_{max} / ha	0,23			0,60			0,1733		
FRP / MW	23,6	35,1	0,67	30,3	25,5	1,19	2,24	1,36	1,65
FRP / kW / m^2	12,48	14,80		6,43	4,27		15,85	9,51	

T - Effective fire temperature; AF - Effective Fire Area; FRP – Fire Radiative Power (Helicopter based data still pre-liminary. Source: Paugam, R., Wooster, M., KCL)

- Error within 35 % relative to ground data
- However:
  - Resamples gras burned on dry savannah
  - How to translate into biomass and CO_2?
  - Additional information is needed to get information on type of vegetation
- Multispectral data can provide more information

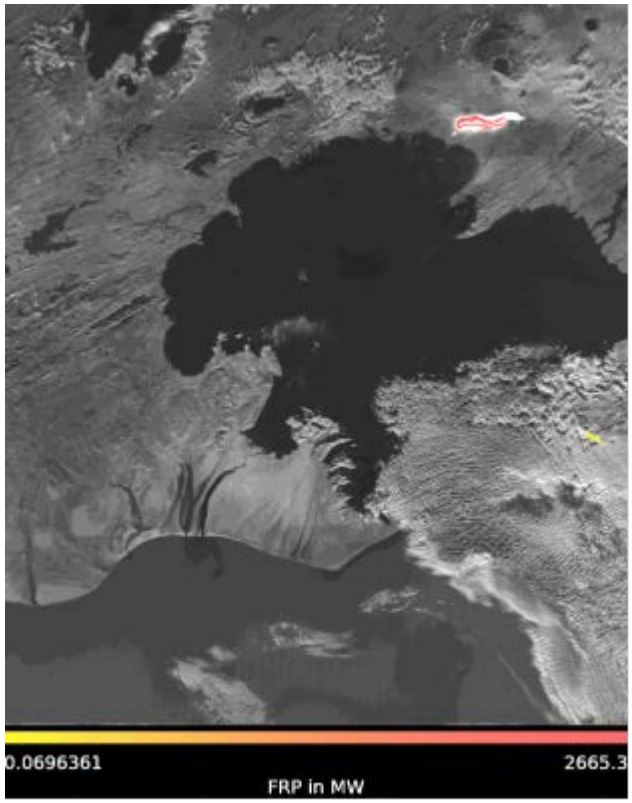
Gas Flaring Estimation

- So far based on visible light
- No quantities in terms of power and therefore CO_2
- Results show that fire algorithm (with lowered thresholds) provides quantities
- Possibly longer integration time needed



- Energy released by gas flare in North Dakota USA in a night time image of the MWIR band on 21. Nov. 2014
- Up to 5 MW
- Background temperature around -8°C

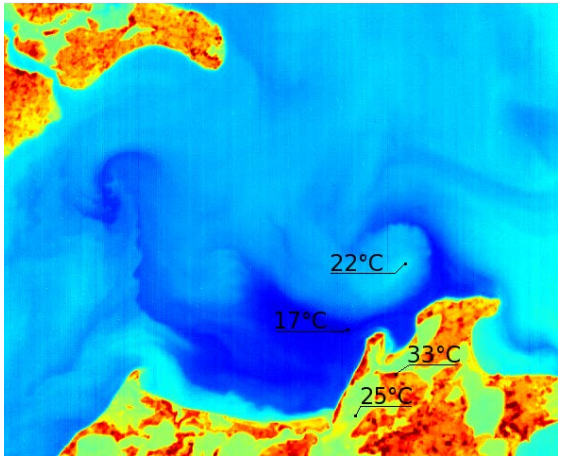
Fire and Ice



- Bardabunga Volcano on Iceland on 21. Sept. 2014
- High contrasts between lava and ice
- Dynamic range is handled using two different integration times per ground sample

Monitoring Waterbodies

- Aim was to show whether it is possible to detect pollutions of water
- E. g. separate oil spills from bio-films
- For „regular“ cases like oil plattforms the geometric reolution (IFOV: 360 m) is to coarse
- Water surface temperatures can be estimated within 1 K accuracy,
- Watermask is needed (NIR channel)



Conclusions

- Performance is as anticipated, quantitative estimations are reliable
- Validation with pre-scribed burnings in various areas should be continued but difficult to schedule
- Satellite images are only a tiny sample regards time, which does not describe the dynamic of a fire fully
- Data reduction on-board
  - cloud screening,
  - concentration on data of fires
- Inclusion of more ground stations
- Multispectral data for better estimating of the background and understanding the effects of fire

Thank you for your attention!

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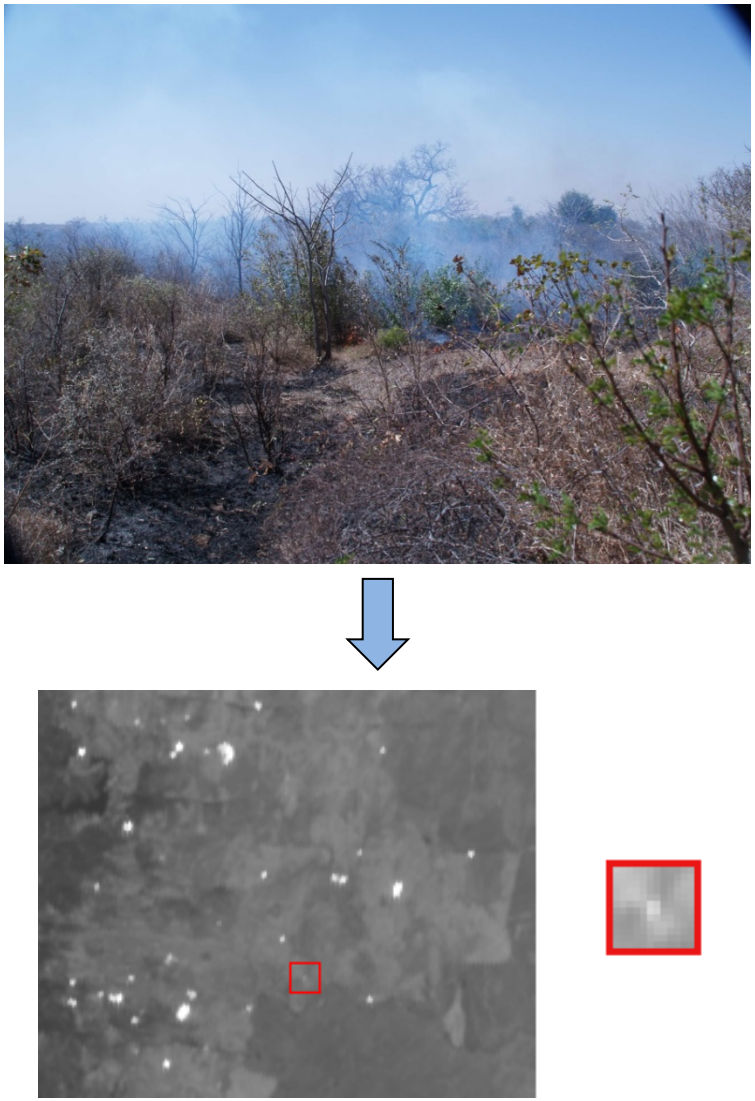
- FireBird Project leader
  Thomas.Terzibaschian@dlr.de
- Questions / Recommandations to Products:
  Olaf.Frauenberger@dlr.de



A smoldering fire along the road side visible in image but not detected as fire.